Amphibian Diversity and Abundance

SOLEC Indicator #4504

Purpose

Assessments of the species composition and relative abundance of calling frogs and toads are used to help infer the condition of Great Lakes basin marshes (i.e. wetlands dominated by non-woody emergent plants). A high proportion of the Great Lakes basin's amphibian species inhabit wetlands during part of their life cycle, and many of the species at risk in the basin are associated with wetlands. Similarly, there is growing international concern about declines of amphibian populations and an apparent increase in rates of deformities. Because frogs and toads are relatively sedentary, have semi-permeable skin, and breed in and adjacent to aquatic systems, they are likely to be more sensitive to, and indicative of, local sources of contamination to wetlands than most other vertebrates.

Ecosystem Objective

The objective is to ensure healthy breeding populations of Great Lakes wetland amphibians by sustaining the necessary quantity and quality of wetland habitat.

State of the Ecosystem

From 1995 through 1999, 11 frog and two toad species were recorded by Marsh Monitoring Program (MMP) participants surveying 354 routes across the Great Lakes basin. Spring Peeper was the most frequently detected species (Table 1) and, as indicated by an average calling code of 2.5, was frequently recorded in full chorus (Call Level Code 3) where it was encountered. Green Frog was detected in more than half of station years and the average calling code indicates this species was usually recorded as Call Level 1. Gray Treefrog, American Toad and Northern Leopard Frog were also common, being recorded in more than one-third of all station years. Gray Treefrog was recorded with the second highest average calling code (1.9), indicating that MMP observers usually heard several individuals with some overlapping calls. Bullfrog, Chorus Frog and Wood Frog were detected in approximately one-quarter of station years. Five species were detected infrequently by MMP surveyors and were recorded in less than three percent of station years.

With only five years of data collected across the Great Lakes basin, the MMP is still quite young as a monitoring program. Trends in amphibian occurrence were assessed for the eight species commonly detected on MMP routes. For each species, a trend was assessed first on a route-by-route basis in terms of the annual proportion of stations with each species present. These route level trends were then combined for an overall assessment of trend for each species. Although some trends were suggested for species such as American Toad and Bullfrog, only the declining trend for Chorus Frog could be resolved with sufficient statistical confidence (i.e. confidence limits do not encompass zero) (Figure 1). Although long-term (1950s to 1990s) losses of Chorus Frog have been recorded in the St. Lawrence River valley

Species Name	% station-years present*	Average calling code
Spring Peeper	69.0	2.5
Green Frog	56.6	1.3
Gray Treefrog	37.9	1.9
American Toad	36.9	1.5
N. Leopard Frog	32.6	1.3
Bullfrog	26.6	1.3
Chorus Frog	25.4	1.7
Wood Frog	18.7	1.5
Pickerel Frog	2.4	1.1
Fowler's Frog	1.4	1.2
Mink Frog	1.3	1.2
Blanchard's Cricket Frog	0.9	1.2
Cope's Gray Treefrog	0.9	1.3

*MMP survey stations monitored for multiple years considered as individual samples

Table 1. Frequency of occurrence and average Call Level Code for amphibian species detected inside Great Lakes basin MMP stations, 1995 through 1999. Average calling codes are based upon the three level call code standard for all MMP amphibian surveys; surveyors record Code 1 (little overlap among calls, numbers of individuals can be determined), Code 2 (some overlap, numbers can be estimated) or Code 3 (much overlap, too numerous to be estimated).

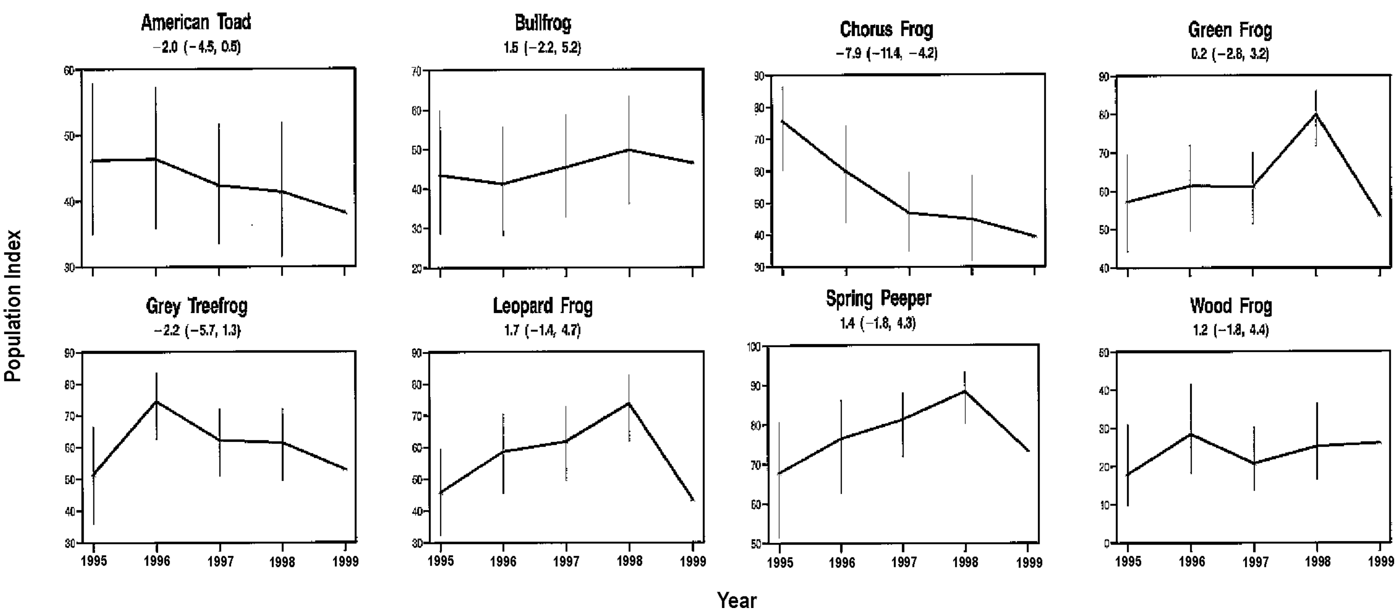

Figure 1. Annual indices of calling amphibian occurrence on MMP routes within the Great Lakes basin, 1995 to 1999. Indices are based on the annual proportion of survey stations with each species present and are defined relative to 1999 values; vertical bars indicate 95% confidence limits around annual indices. The estimated annual percent change (trend) is indicated for each species and the associated lower and upper extremes of 95% confidence limits are enclosed in parentheses.

just outside the Great Lakes basin, this species is known to have population fluctuations, and even regional extinctions, over short time periods due to natural factors such as differences in annual weather conditions (Diagle, 1997). Additional survey and other (e.g. remote sensing) data and detailed analyses will be required to understand how the trends observed for Chorus Frog and other amphibian species relate to changes in Great Lakes wetland habitat conditions.

These data will serve as baseline data with which to compare future survey results and will help provide an understanding of the status and distribution of calling frogs and toads in Great Lakes' wetlands. Anecdotal and research evidence suggests that wide variations in the occurrence of many amphibian species at a given site is a natural and ongoing phenomenon. These variations are apparent for many of the amphibian species recorded by MMP volunteers during the past five years. Additional years of data will help reveal whether these observed patterns (e.g. decline in Chorus Frog station occupancy) continue. Further data are required to conclude whether Great Lakes wetlands are successfully sustaining amphibian populations.

Future Pressures

Current pressures on wetland amphibians will likely continue. Many coastal and inland Great Lakes wetlands are at the lowest elevations in watersheds that support very intensive industrial, agricultural and residential development. Habitat loss and deterioration remain the predominant threat to Great Lakes amphibian populations. More subtle impacts such as water level stabilization, sedimentation, contaminant and nutrient inputs, and the invasion of exotic plants and animals continue to degrade wetlands across the region.

Future Activities

Because of the sensitivity of amphibians to their surrounding environment and the growing international concern about their populations, amphibians in the Great Lakes basin and elsewhere continue to be the focus of monitoring activities. Wherever possible, efforts should be made to maintain wetland habitats and adjacent uplands. Apart from habitat loss, there is also a need to address impacts that are detrimental to wetland health such as inputs of toxic chemicals, nutrients and sediments. Restoration programs are underway for many degraded wetland areas through the work of local citizens, organizations and governments. Although significant progress has been made in this area, further wetland conservation and restoration efforts are needed.

Further Work Necessary

Monitoring of amphibian species will continue in marshes across the Great Lakes basin through the MMP. Continued monitoring of at least 100 routes through 2006 is projected to provide good resolution for several of the amphibians recorded by the MMP. Recruitment and retention of program participants will therefore continue to be a high priority, especially in coastal wetlands. Further work is necessary to establish endpoints for amphibian diversity and abundance. Additional monitoring and other (e.g. remote sensing) data and more detailed analyses are required to examine trends in relation to wetland habitat characteristics and at basinwide, lake basin and other spatial scales. Current monitoring is adapted for large geographic scales, work is currently underway to help refine assessments of bird communities at single sites; additional amphibian work may follow. Assessments of the relationships among station occupancy, calling codes and relative abundance estimates, amphibian population parameters, and critical environmental factors are needed.

Although more frequent updates are possible, reporting trend estimates every five or six years is most appropriate for this indicator. A variety of efforts are underway to enhance reporting breadth and efficiency.

Sources

Diagle, C. 1997. Distribution and Abundance of the Chorus Frog, *Pseudacris triseriata*, in Quebec. In Amphibians in Decline: Canadian Studies of a Global Problem (D. M. Green, ed.). The Society for the Study of Amphibians and Reptiles, Saint Louis, Missouri.

Acknowledgements

Author: Russ Weeber, Bird Studies Canada, Port Rowen, ON.

The Marsh Monitoring Program is delivered by Bird Studies Canada in partnership with Environment Canada's Canadian Wildlife Service and with significant support from the U.S. Environmental Protection Agency's Great Lakes National Program Office and Lake Erie Team. The contributions of all Marsh Monitoring Program staff and volunteers are gratefully acknowledged.

Contaminants in Snapping Turtle Eggs

SOLEC Indicator #4506

Purpose

This indicator measures the concentrations of persistent contaminants in the eggs of Common Snapping Turtles living in wetlands of the Great Lakes basin in order to provide an indirect measure of foodweb contamination and its effects on wetland wildlife.

Methods

The persistent contaminants measured in Snapping Turtle eggs include 59 non-ortho polychlorinated biphenyl (PCB) congeners, six ortho PCB congeners (ortho PCB congeners are more toxic than non-ortho PCB congeners), 20 organochlorine pesticides (including DDT and mirex) and their metabolites, 14 polychlorinated dioxins (PCDD) and 22 furans (PCDF) and mercury. Eggs were collected from the nest and either analyzed for contaminants or incubated artificially to determine hatching success, deformity rates of hatched turtles, and rates of unhatched eggs. Generally, eggs were collected from 1981 to 1991 on the Canadian side of the Lakes at four sites on Lake Ontario (Cootes Paradise/Hamilton Harbour, Lynde Creek, Cranberry Marsh and Trent River), two sites on Lake Erie (Big Creek Marsh/Long Point and Rondeau Provincial Park), one site on the St. Lawrence River (Akwesasne) and one reference site at Lake Sasajewun, an inland lake at Algonquin Provincial Park.

Snapping Turtle eggs have also been collected for contaminant analyses for most years from 1992 to 1999 at most of the study sites listed above. However, these data have not yet been statistically analyzed and will not be discussed at this time.

Ecosystem Objective

The ecosystem objective is to protect wetland wildlife, especially long-lived species like the Snapping Turtle, from the effects of contamination which may include impaired embryonic development.

The mean wet weight concentrations in Snapping Turtle eggs suggested as endpoints are concentrations found in eggs from Big Creek Marsh, Lake Erie which showed no significant difference in hatching rates and deformity rates as compared to the reference site, Lake Sasajewun, Algonquin Park. The following endpoints for mean wet weight concentrations in Snapping Turtle eggs should not be exceeded:

Toxic Equivalents = 158.3 ug/g
Total polychlorinated biphenyls (PCB) = 0.338 ug/g
Total polychlorinated dibenzo dioxins (PCDD) = 1.0 pg/g
Total polychlorinated dibenzo furans (PCDF) = 3.0 pg/g
pp'DDE (metabolite of DDT) = 0.05 ug/g
mirex = 0.0014 ug/g

State of the Ecosystem

Snapping Turtles are ideal candidates as indicators of wetland health due to their sedentary nature, their ability to accumulate high levels of contaminants over their long life-span and their position as top predators in the food chain. Contaminant levels measured in Snapping Turtle eggs are indicative of contaminant levels found in the turtle's diet (about 1/3 fish, 1/3 plants and 1/3 other items including invertebrates and to a lesser degree smaller turtles, birds and snakes). Snapping Turtle eggs collected at two Lake Ontario sites (Cootes Paradise and Lynde Creek) had the highest PCDD concentrations (notably 2,3,7,8-TCDD; Figure 1) and number of

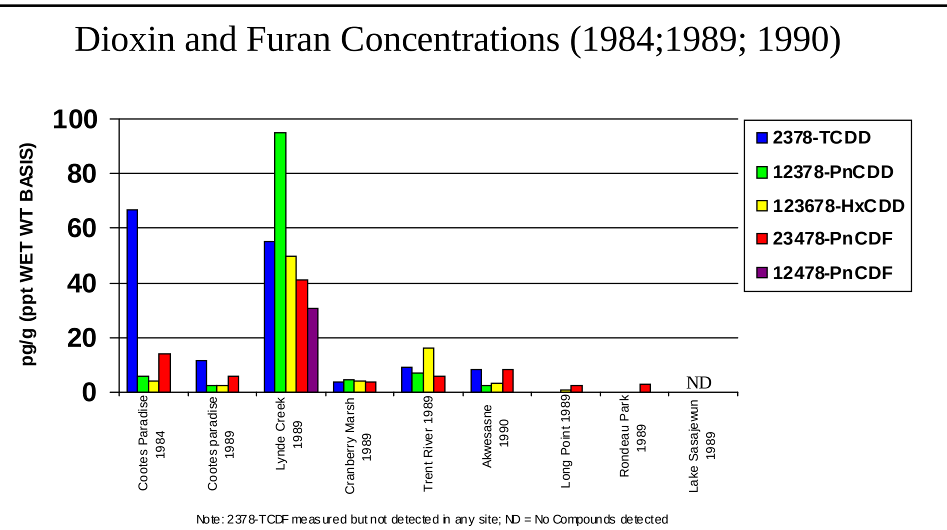

Figure 1. Dioxin and furan concentrations (1984; 1989/90) in Snapping Turtle eggs at Canadian Great Lakes study sites
(Source: Bishop and Gendron, 1998).

detectable PCDF congeners (twenty versus six at all other sites). Eggs from Cranberry Marsh (Lake Ontario) had similar levels of PCBs (Figure 2) and organochlorines (not shown) compared to Lake Erie sites but higher concentrations and a greater number of PCDD and PCDF congeners were detected at this site relative to Lake Erie sites (Figure 1). Eggs from Akwesasne contained the highest level of PCBs relative to all other sites (Figure 2).

Temporal trends for contaminants indicate that for eggs at two Lake Ontario sites (Cootes Paradise and Lynde Creek), levels of PCBs and DDE (not shown) increased significantly from 1984 to 1990/91 (Figure 2). Importantly, levels of PCDDs (including 2,3,7,8-TCDD) and PCDFs decreased significantly at Cootes Paradise from 1984 to 1989 (Figure 1). At Lake Erie and the reference lake sites, decreasing or stable levels of contaminants in eggs were reported from 1984 to 1991.

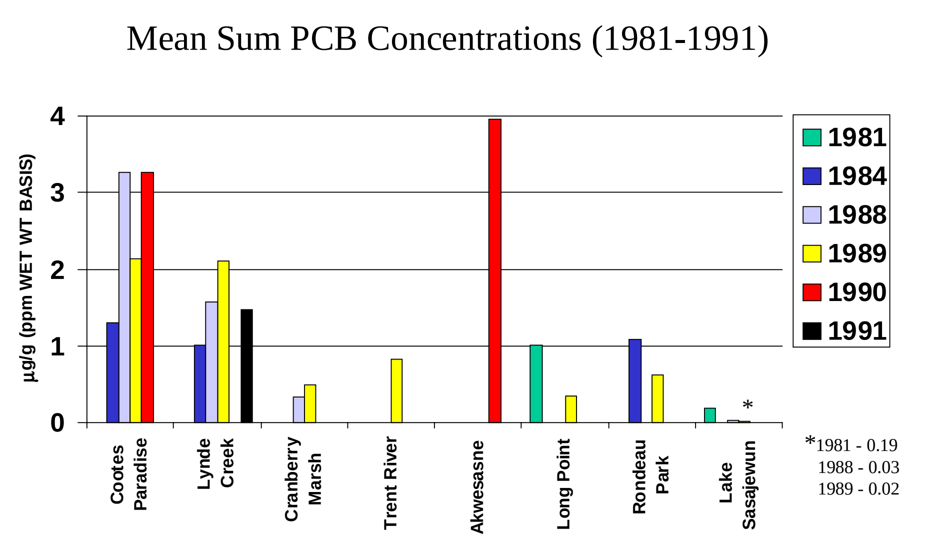

Figure 2. Mean sum PCB concentrations (1981-1991) in Snapping Turtle eggs at Canadian Great Lakes study sites and one inland reference site.
(Source: Bishop and Gendron, 1998).

Bishop *et al.* (1991) have demonstrated that eggs with the highest contaminant levels also show the poorest developmental success. Rates of abnormal development of Snapping Turtle eggs from (1986-1991) were highest at all four Lake Ontario sites compared to all other sites studied (Figure 3). Rates were similar between the one Lake Erie site sampled (Long Point) and the reference inland lake.

Future Pressures

High contaminant levels associated with eggs of Lake Ontario turtles may be due, in part, to a diet of migratory Lake Ontario fish, including carp and other large long-lived fish species. Similarly, low contaminant levels observed in Lake Erie eggs may be due to a more diversified diet of less contaminated smaller fish and other local diet items. Continuing contaminant exposures in Lake Ontario and St. Lawrence River Snapping Turtles will likely only be alleviated through natural biological loss of persistent chemicals from the environment (e.g. sedimentation) and further reductions of atmospheric, point and non-point source loadings into the Lake Ontario and St. Lawrence River ecosystems.

Future Activities

Similar to other SOLEC coastal wetland indicators, this indicator is currently being reviewed by the Canadian Wildlife Service (CWS) and the SOLEC coastal wetlands core group. For CWS, this program is still in its experimental stages and further analyses of the data are required to determine whether this indicator will be adopted as part of ongoing wildlife monitoring activities. A new binational Great Lakes coastal wetland indicator consortium, supported by the U.S. Environmental Protection Agency, will also evaluate the suitability of this indicator in assessing coastal wetland health. Pending further consideration, analyses of contaminant levels in Snapping Turtle eggs at selected study sites and studies of rates of abnormal development may continue in future years as part of a long-term strategy for monitoring foodweb contamination and its effects on wetland wildlife.

Further Work Necessary

In order to use this indicator at a basin-wide scale, additional monitoring sites need to be established at representative sites in the United States and the upper Great Lakes. Evaluation of other biological endpoints such as disruption of hormone levels and development of secondary sexual characteristics in Snapping Turtles would also be of value.

The effects of contaminants on the Great Lakes ecosystem, including wetlands, have been studied for many years. The parties to the Great Lakes Water Quality Agreement (U.S. and Canada) are committed to the virtual elimination of discharge associated with any or all persistent toxic substances.

Sources

Bishop, C.A., Brooks, R.J., Carey, J.H., Ng, P., Norstrom, R.J. and Lean, D.R.S. 1991. The case for a cause-effect linkage between environmental contamination and development in eggs of the Common Snapping Turtle (*Chelydra serpentina*) from Ontario, Canada. J. Toxicol. Environ. Health 33: 512-547.

Bishop, C.A. and Gendron, A.D. 1998. Reptiles and amphibians: shy and sensitive vertebrates of the Great Lakes basin and St. Lawrence River. Environ. Monit. Assess. 53: 225-244.

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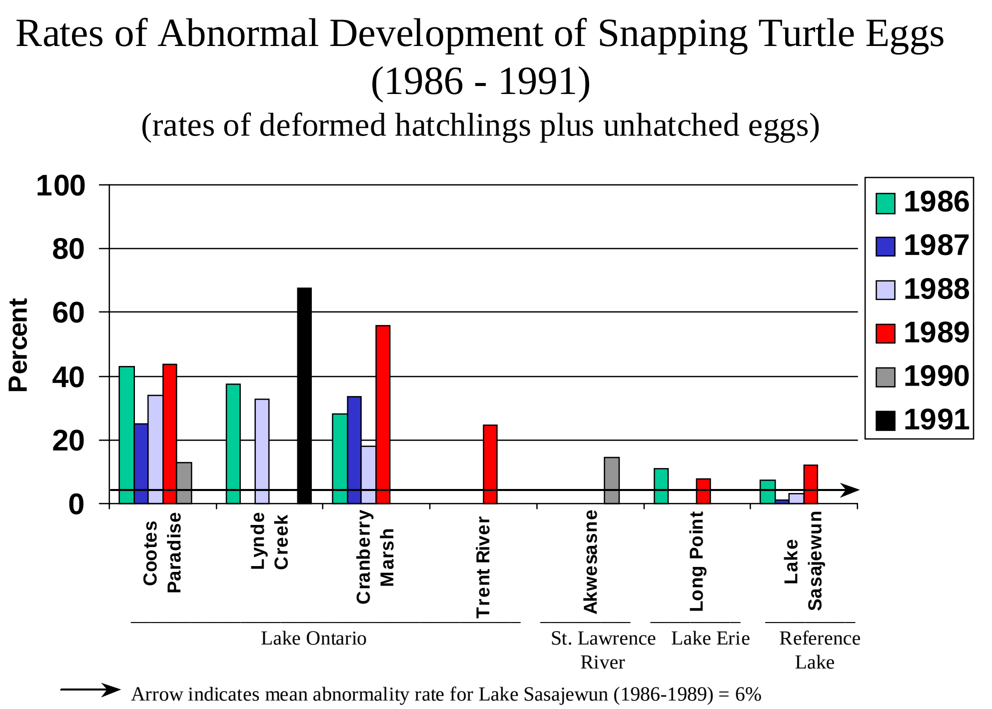

Figure 3. Rates of abnormal development (i.e., rates of deformed hatchlings plus unhatched eggs) of Snapping Turtle eggs (1986-1991) at Canadian Great Lakes study sites and one inland reference site.
(Source: Bishop and Gendron, 1998)

Wetland-Dependent Bird Diversity and Abundance

SOLEC Indicator #4507

Purpose

Assessments of the diversity and abundance of wetland-dependent birds in the Great Lakes basin are used to evaluate the health and function of wetlands. Breeding birds are valuable components of Great Lakes wetlands and rely on the physical, chemical and biological health of their habitats. Because these relationships are particularly strong during the breeding season, the presence and abundance of breeding individuals can provide a source of information on wetland status and trends. When long-term monitoring data are combined with an analysis of habitat characteristics, trends in species abundance and diversity can contribute to an assessment of the ability of Great Lakes coastal wetlands to support birds and other wetland-dependent wildlife. Populations of several wetland-dependent birds are at risk due to the continuing loss and degradation of their habitats.

Geographically extensive and long-term surveys of wetland-dependent birds are possible through the coordination of skilled volunteer naturalists in the application of standardized monitoring protocols. Information on the abundance, distribution and diversity of marsh birds provides needed measures of their population trends, and with their habitat associations, can contribute to more effective, long-term conservation strategies.

Ecosystem Objective

The objective is to ensure healthy breeding populations of Great Lakes wetland-dependent birds by sustaining the necessary quantity and quality of wetland habitat.

State of the Ecosystem

From 1995 through 1999, 53 species of birds that use marshes (wetlands dominated by non-woody emergent plants) for feeding, nesting or both were recorded by Marsh Monitoring Program (MMP) volunteers at 322 routes throughout the Great Lakes basin. Among the bird species that typically feed in the air above marshes, Tree Swallow and Barn Swallow were the two most common. Red-winged Blackbird was the most commonly recorded marsh nesting species, followed by Swamp Sparrow, Common Yellowthroat and Marsh Wren. Individual bird species varied considerably in their distribution among lake basins; patterns likely influenced by differences in species geographic range and variation among basins in sampled wetland habitat characteristics such as permanency, size, and dominant vegetation type.

With only five years of data collected across the Great Lakes basin, the MMP is still quite young as a monitoring program. Bird species occurrence and numbers, and their activity and likelihood of being observed, vary naturally among years and within seasons. Although results are still preliminary, trends are presented for several birds recorded on Great Lakes MMP routes (Figure 1a,b). Population indices and trends (i.e. average annual percent change in population index) are presented for species with statistically significant trends between 1995 and 1999. Species with significant basin-wide declines were Pied-billed Grebe, Blue-winged Teal, American Coot, undifferentiated Common Moorhen/ American Coot, and Black Tern (Figure 1a). Although declines for Tree Swallow and Red-winged Blackbird were not quite statistically significant, trends for these species are also presented because they are particularly widespread and common marsh nesting birds. Statistically significant basin-wide increases were observed for Canada Goose, Mallard, Chimney Swift, Northern Rough-winged Swallow, Common Yellowthroat and Common Grackle (Figure 1b). Each of the declining species depends upon wetlands for breeding but, because they use wetland habitats almost exclusively, the Pied-billed Grebe, American Coot, Common Moorhen, and Black Tern are particularly dependent on the availability of healthy wetlands. Although declines in these wetland specialists and increases in some wetland edge and generalist species (e.g. Common Yellowthroat and Canada Goose) suggest trends in wetland habitat conditions, additional years of data and more detailed analyses are required to understand how these patterns relate to trends in Great Lakes wetland functions.

Future Pressures

Future pressures on wetland-dependent birds will likely include continuing loss and degradation of important breeding habitats through wetland loss, water level stabilization, sedimentation, contaminant and nutrient inputs, and the invasion of exotic plants and animals.

Future Activities

Wherever possible, efforts should be made to maintain high quality wetland habitats and adjacent upland areas. In addition to loss, there is a need to address impacts that are detrimental to wetland health such as water level stabilization, invasive species and inputs of toxic chemicals, nutrients and sediments. Restoration programs are underway for many degraded wetland areas through the work of local citizens, organizations and governments. Although significant progress has been made, further conservation and restoration work is needed.

Further Work Necessary

Monitoring of wetland-dependent bird species will continue across the Great Lakes basin through the MMP. Continued monitoring of at least 100 routes through 2006 is projected to provide good resolution for most of the wetland-dependent birds recorded by the MMP. Recruitment and retention of program participants will therefore continue to be a high priority, particularly in coastal wetlands. Further work is necessary to establish endpoints for bird diversity and abundance. Additional monitoring and other (e.g. remote sensing) data and more detailed analyses are required to examine trends in relation to wetland habitat characteristics at basinwide, lake basin and other spatial scales. Current monitoring is adapted for large geographic scales, work is currently underway to help refine assessments of bird communities at single sites. Assessments of the relationships among count indices, bird population parameters, and critical environmental factors are needed.

Although more frequent updates are possible, reporting trend estimates every five or six years is most appropriate for this indicator. A variety of efforts are underway to enhance reporting breadth and efficiency.

Acknowledgements

Author: Russ Weeber, Bird Studies Canada, Port Rowen, ON. The Marsh Monitoring Program is delivered by Bird Studies in partnership with Environment Canada's Canadian Wildlife Service and with significant support from the U.S. Environmental Protection Agency's Great Lakes National Program Office and Lake Erie Team. The contributions of all Marsh Monitoring Program staff and volunteers are gratefully acknowledged.

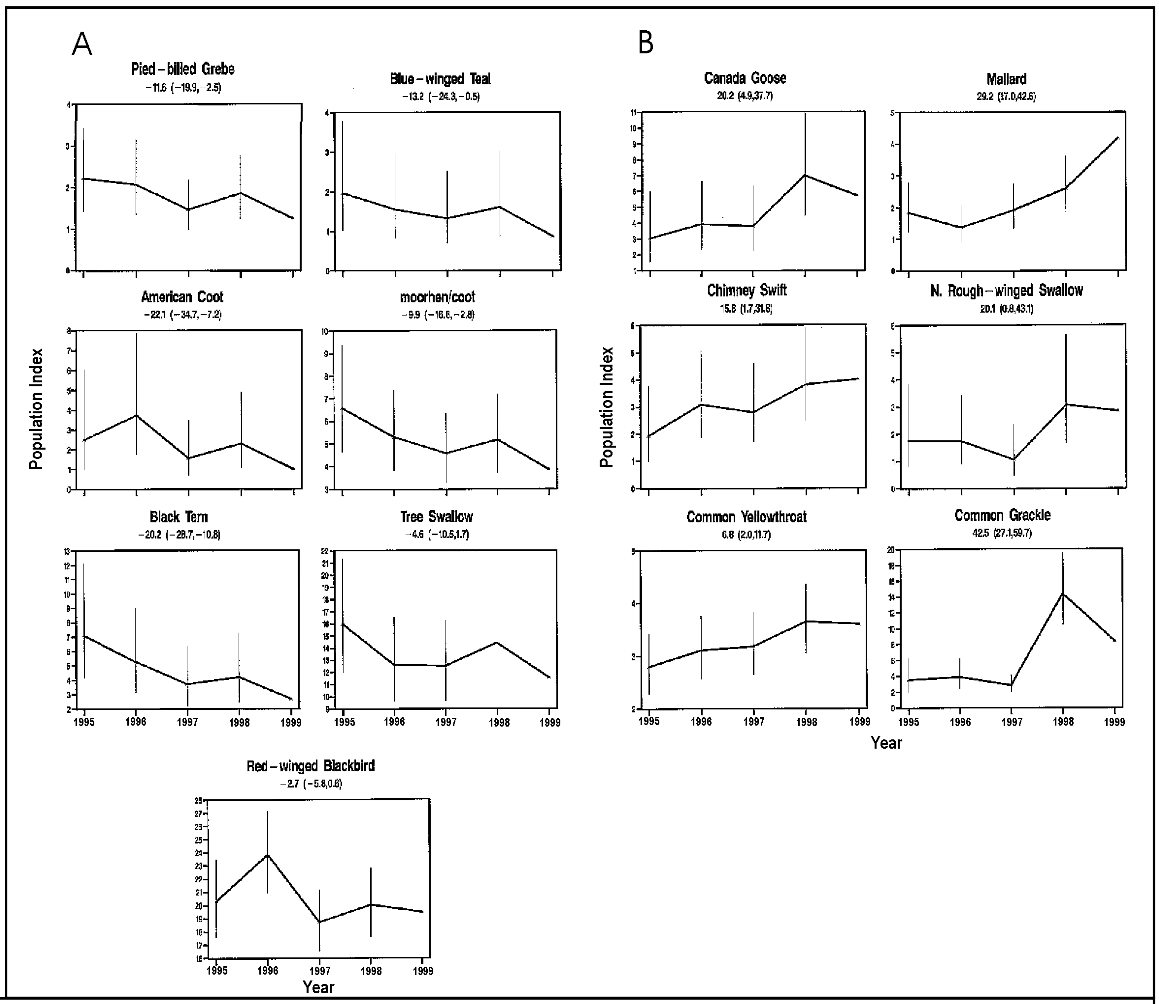

Figure 1: Annual population indices of a) declining and b) increasing marsh nesting and aerial foraging bird species detected on Great Lakes basin MMP routes, 1995 through 1999. Population indices are based on counts of individuals inside the MMP station boundary and are defined relative to 1999 values; vertical bars indicate 95% confidence limits around annual indices. The estimated annual percent change (trend) are indicated for each species and the associated lower and upper extremes of 95% confidence limits are enclosed in parentheses.

Coastal Wetland Area by Type

SOLEC Indicator #4510

Please note - figures 2 & 3 for this indicator are unavailable at this time

Purpose

The purpose of this indicator is to examine and better understand periodic changes in area of coastal wetland types, taking into account natural variations. The area indicator needs to be evaluated in terms of wetland quality by looking at both change in areal extent and change within wetlands, in concert with other indicators.

Coastal wetlands include a range of habitats from bogs and treed swamps to emergent marshes. They also have many configurations. Being open to the lake, some are more susceptible to the influence of lake level changes than others which may be behind barrier beaches. Given the tremendous natural variation that can occur in both quality and area as a result of fluctuating water levels (e.g., Lake St. Clair wetlands change in size by up to 300 percent depending on water levels), this factor is paramount in the interpretation of trends in wetland area. For example, recent low water levels have moved wetland vegetation lakeward (where bottom topography is suitable), shrinking some and increasing others in addition to exposing many mudflats. Yet when the waters rise again, through exposure during the low water period, the seedbank may result in a reinvigoration of wetland vegetation.

Ecosystem Objective

The ecosystem objective is to reverse the trend toward loss and degradation of Great Lakes coastal wetlands, ensuring adequate representation of wetland types across their historical range.

State of the Ecosystem

Wetlands continue to be lost and degraded, yet the ability to track and determine the extent and rate of this loss in a standardized way is not yet feasible. The need to know the location, type and area of Great Lakes coastal wetlands has been identified by a number of individuals, groups and agencies for many years in order to understand the rate and distribution of the changes and track conservation efforts. For example, in preparation for SOLEC '96, the possibility of pulling together a map of Great Lakes coastal wetlands was thoroughly investigated and was determined to be unfeasible at that time. In addition to distribution, the health and status of remaining Great Lakes coastal wetlands, continues to be unknown.

A number of approaches to establish a baseline and determine trends in wetland area have been and will continue to be considered. Unfortunately, none of these exactly match the method outlined for this indicator at SOLEC '98. It is hoped that a new Great Lakes wetlands indicators consortium, which is supported by the US Environmental Protection Agency, will debate the merits of various indicators and approaches, including wetland area.

In the meantime, many efforts have been initiated to estimate wetland area. For example, on the Canadian side of the basin, development of the Ontario Coastal Wetland Atlas provides the most comprehensive and current data base of Ontario Great Lakes wetlands. It includes a relatively complete, spatially referenced map and data base of Canada's Great Lakes coastal wetlands present as of the mid-1980s. It consolidates and enhances information from a variety of sources including: Ontario Ministry of Natural Resources' (OMNR) wetland evaluations, Environment Canada's Environmental Sensitivity Atlases, Natural Heritage Information Centre, OMNR's Natural Areas Database and other site specific studies.

Adding up the area of individual wetlands from the Ontario Atlas will provide an initial estimate of total Canadian Great Lakes coastal wetland area. Unfortunately, this is unlikely to be a method which is repeated since it is labour intensive, expensive, and covers a very large geographic area. Therefore, it does not represent the baseline for a trend, rather it provides a very useful point-in-time reference which aids in the selection of representative sites for monitoring area and other indicators, and improves understanding of wetland change.

The Wetland Inventory for Research and Education Network (WIRENET), which was based on a similar, but less extensive process than the Atlas, including mid-1980s wetland evaluations, provides an on-line map of Ontario coastal wetlands at:

www.on.ec.gc.ca/glimr/wirenet/. WIRENET was used in the work on coastal wetland biodiversity investment areas for SOLEC '98.

Other methods to look at trends in coastal wetland area rely on remotely sensed data. For example, the U.S. Fish and Wildlife Service published the National Wetland Inventory (NWI) in 1982, based on the analysis of aerial photographs with ground-truthing. The NWI includes delineated wetland types using the system of Cowardin et al. (1979). Updates are to be prepared every 10 years with the first one in 1990 and the 2000 update due soon. Updates are based on a statistical sampling of wetlands, not on a full set of aerial photos. The NWI, although very useful, does not specifically identify coastal wetlands.

In Canada, trends in wetland area, vegetation communities and adjacent land uses have been mapped and digitized for eight coastal wetlands for seven different years between 1934 and 1995. These data are based on air photo interpretation and include the following wetlands: Lake St. Clair marshes, Big Creek-Holiday Beach, Rondeau Bay North Shore, Turkey Point, Oshawa Second Marsh, Presqu'ile Marsh, Dunnville Marsh and Long Point (see Fig. 1). There are plans to add additional wetlands to this "Trends Through Time" database in order to increase the representativeness of the sites selected for the basin. Plans are also underway to investigate the potential to use these sites to indicate and interpret change (Fig. 2) and status of coastal wetlands at a basinwide scale (Fig. 3).

Numerous research efforts are underway to assess the use of remote sensing technologies, and in some cases combine the results of satellite remote sensing, aerial photography and field work to document recent wetland loss. It is hoped that in the future, remote sensing will be used to provide an overview and facilitate a binational map of Great Lakes coastal wetlands as well as to establish a consistent methodology for tracking and anticipating change and facilitate faster updates and better tracking of wetland change in areas of high land-use change.

Future Pressures

There are many stressors which have and continue to contribute to the loss and degradation of coastal wetland area. These include: filling, dredging and draining for conversion to other uses such as urban, agricultural, marina, and cottage development; shoreline modification; water level regulation; sediment and nutrient loading from watersheds; adjacent landuse; invasive species, particularly exotics; and climate variability and change.

Figure 1. Location of eight coastal wetlands for "Trends Through Time" database.

Many of these stressors require direct human action to implement, and thus, with proper consideration of the impacts, can be reduced. The natural dynamics of wetlands must be understood. Global climate variability and change have the potential to amplify the dynamics by reducing water levels in the Lakes in addition to changing seasonal storm intensity and frequency, water level fluctuations and temperature.

Because of growing concerns around water quality and supply, which are key Great Lakes conservation issues, and the role of wetlands in flood attenuation, nutrient cycling and sediment trapping, wetland changes will continue to be monitored closely.

Future Activities

There are activities underway on many fronts and at many scales to conserve remaining wetlands. These include: improving legislation, policies and permitting processes; communication and outreach activities to promote good stewardship; habitat and biodiversity protection programs; habitat rehabilitation programs; watershed stewardship; and research. One example includes the current review of the Water Level Regulation Plan for Lake Ontario. In determining revisions to the plan, this review will consider wetlands, fisheries and other environmental and emerging issues along with the traditional interests of hydropower, commercial navigation and shoreline property owners.

Being able to track, document and anticipate changes in coastal wetland area, distribution and diversity will direct wetland conservation to prevent the loss of key areas and maintain and sustain hydrologic function in the Great Lakes basin.

Further Work Necessary

The difficult decisions on how to address human-induced stressors causing wetlands loss have been considered for some time. A better understanding of wetland function will help to assess exactly what is being lost. An educated public is critical to ensuring that wise decisions about the stewardship of the Great Lakes basin ecosystem are made. Better platforms for getting understandable information to the public are needed.

As mentioned previously, it is hoped that a new binational Great Lakes coastal wetland indicator consortium will wrestle with all of the difficult issues with respect to the most appropriate, implementable method for tracking trends in area as well as the frequency with which it is monitored and reported, in order to establish the best technique.

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Authors: Lesley Dunn, Canadian Wildlife Service, Environment Canada, Downsview, ON and Laurie Maynard, Canadian Wildlife Service, Environment Canada, Guelph, ON.

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Effect of Water Level Fluctuations

SOLEC Indicator #4861

Purpose

The purpose of this indicator is to examine the historic water levels in all of the Great Lakes, and compare these levels and their effects on wetlands with post-regulated levels in Lakes Superior and Ontario, where water levels have been regulated since about 1914 and 1959, respectively. Naturally fluctuating water levels are known to be essential for maintaining the ecological health of Great Lakes shoreline ecosystems, especially coastal wetlands. Thus, comparing the hydrology of the Lakes serves as an indicator of degradation caused by the artificial alteration of the naturally fluctuating hydrological cycle. Furthermore, water level fluctuations can be used to examine effects on wetland vegetation communities over time as well as aid in interpreting estimates of coastal wetland area, especially in those Great Lakes for which water levels are not regulated.

Ecosystem Objective

The ecosystem objective is to maintain the diverse array of Great Lakes coastal wetlands by allowing, as closely as is possible, the natural seasonal and long-term fluctuations of Great Lakes water levels. Great Lakes shoreline ecosystems are dependent upon natural disturbance processes, such as water level fluctuations, if they are to function as dynamic systems. Naturally fluctuating water levels create ever-changing conditions along the Great Lakes shoreline, and the biological communities that populate these coastal wetlands have responded to these dynamic changes with rich and diverse assemblages of species.

State of the Ecosystem

Water levels in the Great Lakes have been measured since 1860, but even 140 years is a relatively short period of time when assessing the hydrological history of the Lakes. Sediment investigations conducted recently by Thompson and Baedke on the Lake Michigan-Huron system indicate quasi-periodic lake level fluctuations (Figure 1), both in period and amplitude, on an average of about 160 years, but ranging from 120 - 200 years.

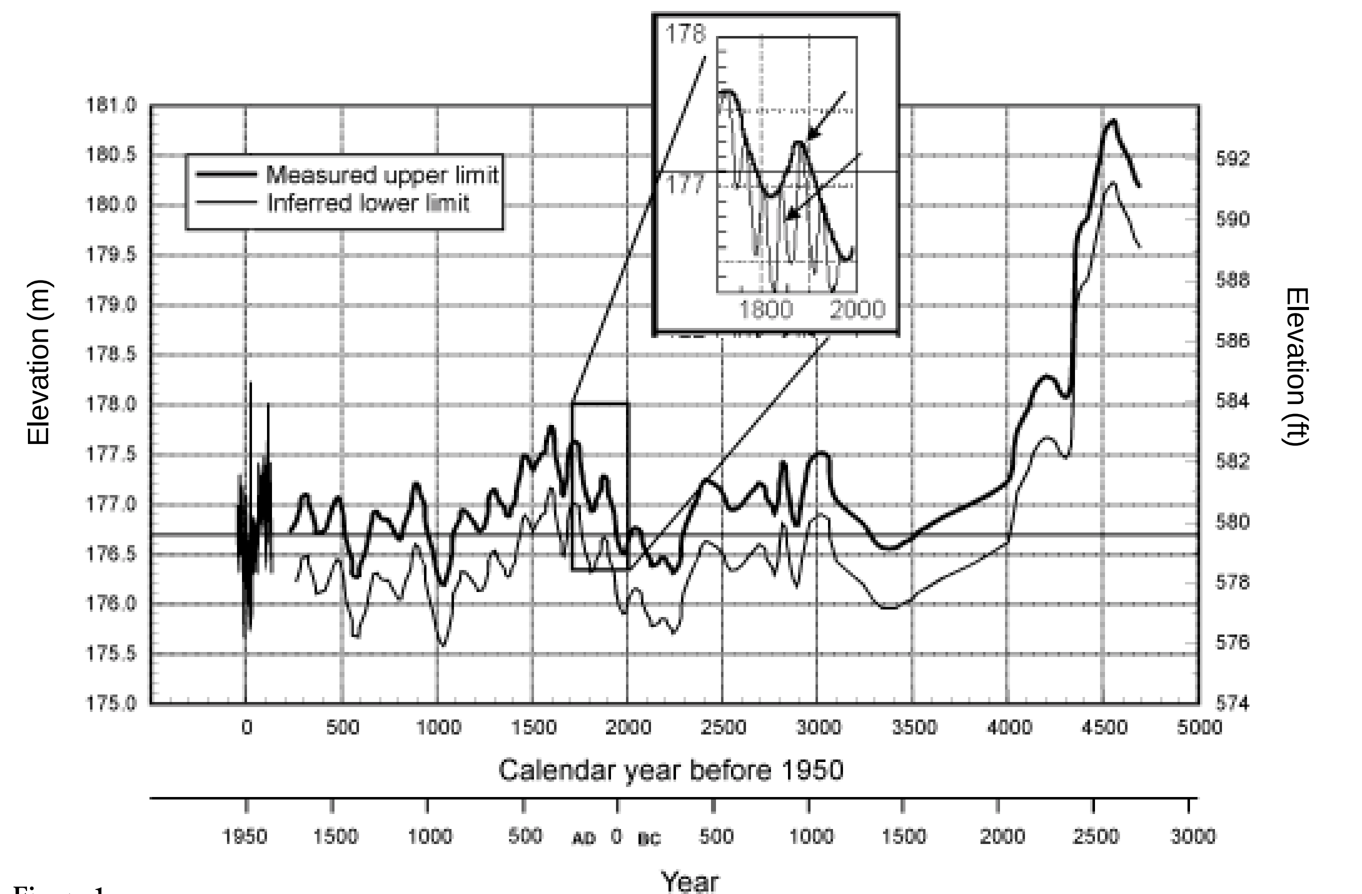

Figure 1.

Within this 160-year period, there also appear to be sub-fluctuations of approximately 33 years. Therefore, to assess water level fluctuations and wetland trends, it is necessary to look at long-term data.

Because Lake Superior is at the upper end of the water-shed, the fluctuations have less amplitude than the other Lakes. Lake Ontario (Figure 2), at the lower end of the watershed, more clearly shows these quasi-periodic fluctuations and the almost complete elimination of the high and low levels since the Lake level began to be regulated in 1959, and more rigorously since 1976. For example, the 1986 high level that was observed in the other Lakes was eliminated from Lake Ontario. The level in Lake Ontario after 1959 contrasts that Lake Michigan-Huron (Figure 3), which shows the more characteristic high and low water levels.

Seasonal water level fluctuations result in higher summer water levels and lower winter levels. Additionally, the often unstable summer water levels ensure a varied hydrology for the diverse plants species inhabiting coastal wetlands. Without the seasonal variation, the wetland zone would be much narrower and less diverse. Even very short-term fluctuations resulting from changes in wind direction and barometric pressure can substantially alter the area inundated, and thus, the coastal wetland community.

Long-term water level fluctuations, of course, have an impact over a longer period of time. During periods of high water, there is a die-off of shrubs, cattails, and other woody or emergent species that cannot tolerate long periods of increased depth of inundation. At the same time, there is an expansion of aquatic communities, notably submergents, into the newly inundated area. As the water levels recede, seeds buried in the sediments germinate and vegetate this newly exposed zone, while the aquatic communities recede outward back into the Lake. During periods of low water, woody plants and emergents expand again to reclaim their former area as aquatic communities establish themselves further outward into the Lake.

Lake Ontario Actual Level

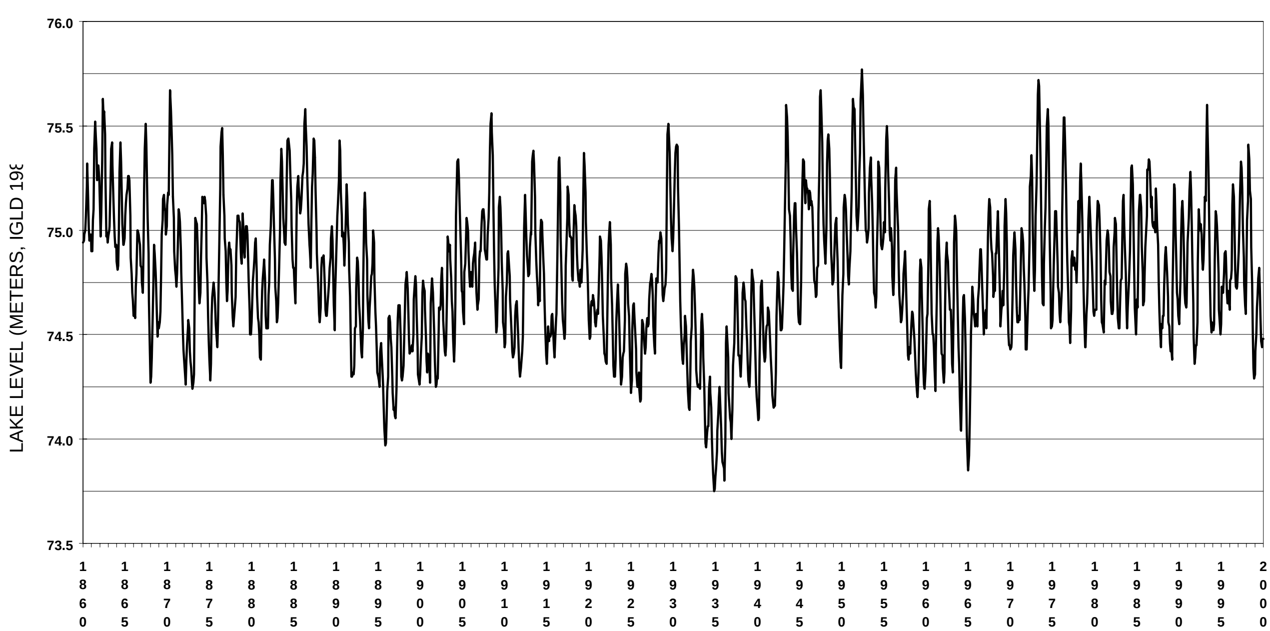

Figure 2.

The significance of seasonal and long-term water level fluctuations on coastal wetlands is perhaps best explained in terms of the vegetation, which, in addition to its own diverse composition, provides the substrate, food, cover, and habitat for many other species dependent on coastal wetlands.

The long-term high-low fluctuation puts natural stress on coastal wetlands, but is vital in maintaining wetland diversity. It is the mid-zone of coastal wetlands that harbours the greatest biodiversity. Under more stable water levels, coastal wetlands occupy narrower zones along the Lakes and are considerably less diverse, as the more dominant species, such as cattails, take over to the detriment of those less able to compete under a stable water regime. This is characteristic of many of the coastal wetlands of Lake Ontario, where water levels are regulated.

Future Pressures
Future pressures on the ecosystem include additional withdrawals or diversions of water from the Lakes, or additional regulation or smoothing of the high and low water levels. These potential future pressures will require direct human intervention to implement, and thus, with proper consideration of the impacts,
can be prevented. The more insidious impact could be due to global climate variability and change. The quasi-periodic fluctuations of water levels are the result of climatic effects, and global climate change has the potential to greatly alter the water levels in the Lakes.

Future Activities
A new reference study is planned for Lake Ontario to develop a more ecologically compatible plan for water level regulation. With this work, there is hope that Lake Ontario's coastal wetlands will benefit from a better plan for managing Lake water levels.

Continued monitoring of water levels in all of the Great Lakes is vital to understanding coastal wetland dynamics and the ability to assess wetland health on a large scale. Fluctuations in water levels are the driving force behind coastal wetland biodiversity and overall wetland health. Their effects on wetland ecosystems must be recognized and monitored throughout the Great Lakes basin in both regulated and unregulated Lakes.

Further Work Necessary
The difficult decisions on how to address human-induced global climate change extend far beyond the bounds of Great Lakes coastal wetlands, but this could be a major cause of lowered water levels in the Lakes in future years.

Also, an educated public is critical to ensuring wise decisions about the stewardship of the Great Lakes Basin ecosystem, and better platforms to getting understandable information to the public are needed.

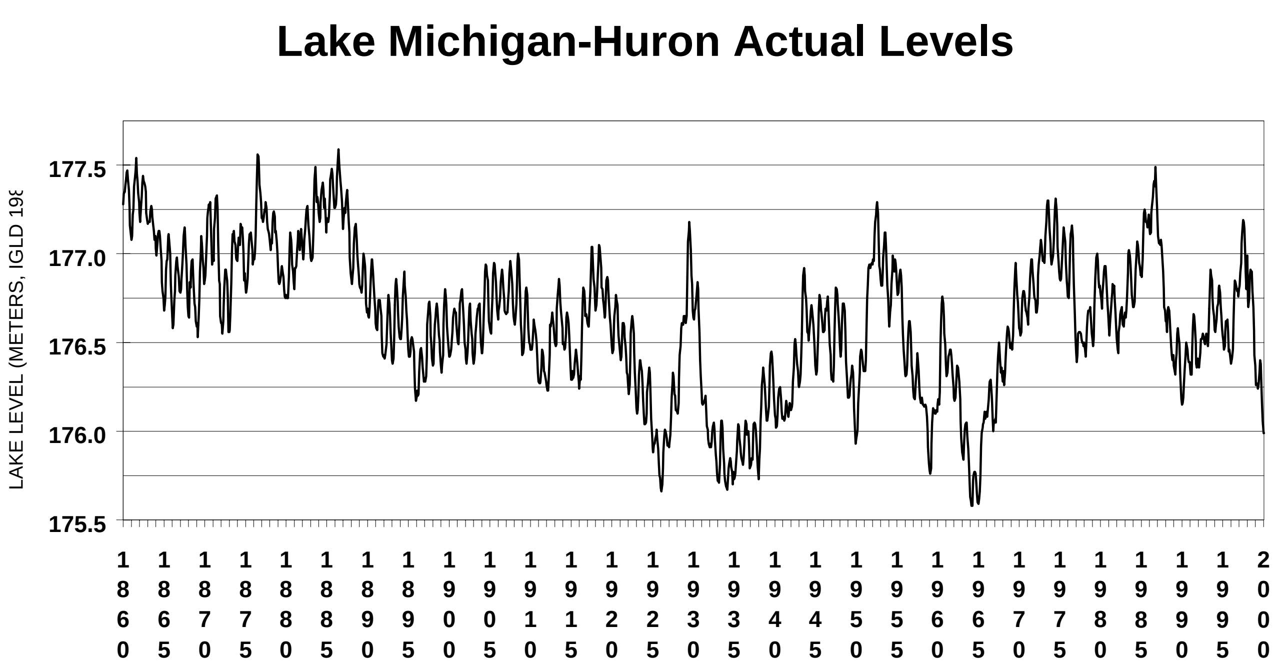

Figure 3.

Because Lake level fluctuations occur over long quasi-periodic fluctuations, modification of this indicator is necessary from that presented at SOLEC in 1998.

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